Provisioning process: from customer needs to resource allocation
- An application to VPN provisioning -

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Abstract - *The aim of this work is to improve the effectiveness of the end-to-end provisioning on telecom operator's networks. This paper focuses on the functional dimension of the provisioning. Starting from the results of standardization bodies on network management and taking into account the complexity of the provisioning process, from customer request to effective resource allocation, we propose a decomposition of the process to optimize and urbanize the components and flows in order to obtain a fast RoI and to meet time-to-market criterion. Moreover, we provide an example of a VPN provisioning process to illustrate our contributions related to the subject.*

keywords – processes, management layers, provisioning.

1. Introduction

The challenge for today's operators is to stay ahead of the "game". The size and complexity of the global telecommunication and media industry is presenting a major challenge. And as if that weren't enough, today's environment is changing at ever-increasing speed. Deregulation is intensifying, new network equipments are being launched every day and new standards are being promoted.

In this context, the speed of *availability* of new services is crucial. *Time-to-market* pressure, the possibility of effectively meeting customer requirements and fast *RoI* (Return of Investment) are the key to service provider and network operator success. The current organizations are not always prepared for this end and have difficulty supporting new needs and deploying new services. The various VPN (Virtual Private Network) service requests with differentiated QoS (Quality of Service) and the new specific services promoted by operators require great *flexibility* and an easy evolution and adaptation of operational support systems.

The problem is that provisioning is increasingly complex and expensive in time. A customer requests a service to the CRM (customer relationship management). The CRM sends provisioning requests to the network and service management systems. Considering the complexity of required services, according to the customer SLA (Service Level Agreement) contract [1], and the expansion of networks, there will be several ways to deal with these demands and synchronization mechanisms are necessary between provisioning activities and the activation of requested services. This synchronization requires management and maintenance of coherence between the various databases used.

In this article, we focus on the *provisioning process*. We will bring some answers to operators' key preoccupations which we have identified such as: satisfying the time-to-market criterion, ensuring fast RoI, process flexibility for facing new needs and deploying new services, ensuring the interaction between BSS (Business Support System) applications, receiving customers requests, and OSS(Operational Support System) applications that support network and service management.

To achieve this goal, the paper is organized as follows. In section 2, we identify the principal elements from TMN (Telecommunication Management Network), TMF (TeleManagement Forum) and WfMC (Workflow Management Coalition), which we consider as essential within the framework of our work. After having applied them, section 3 presents our proposal for an efficient end-to-end provisioning process model. To illustrate our contribution we present in section 4 a workflow for VPN provisioning. Conclusions and future works are given in the last section.

2. Management standards benefits for processes

In this section, we present the main results of TMN, TMF and WfMC *within the process and provisioning frameworks*. Their contributions and the relations between their results will also be underlined. Our contribution, in this section, consists in identifying only the important points which will help to solve our problem of provisioning process specification.

2.1. TMN

The functional architecture of TMN [2][3][4] (fig.1) divides the TMN domain into various building blocks. Each one carries out specific TMN management functions [5]. TMN organizes management functions according to four levels. These levels form a logical hierarchy of management. They also correspond to a type of functional grouping according to enterprise management domains. Provisioning uses configuration management functions [5]. These functions cover, in theory, all TMN management layers: from BML to EML. TMN uses an ascending approach (Bottom-UP). It gives more details for NML and EML than BML and SML. The current M3400 TMN recommendation does not cover the highest two levels of the pyramid. TMN also presents some management scenarios, but it does not propose any definition, any model or concepts related to management processes.

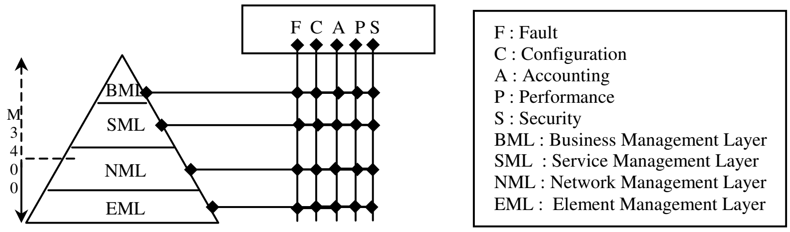


Figure 1. TMN functional architecture.

2.2. TMF

The TMF developed models that define enterprise management processes, filling the gap left by TMN. The TMF has provided the definition of two process charts: TOM and eTOM.

2.2.1 Telecom Operations Map (TOM)

In the TOM [6][7], processes are represented at each management level (fig.2). For each process, the principal activities are mentioned. Input and output information flows, which initiate the activities, are represented too. An example is given in figure 3 which shows the position of the network provisioning process with regard to TMN pyramid.

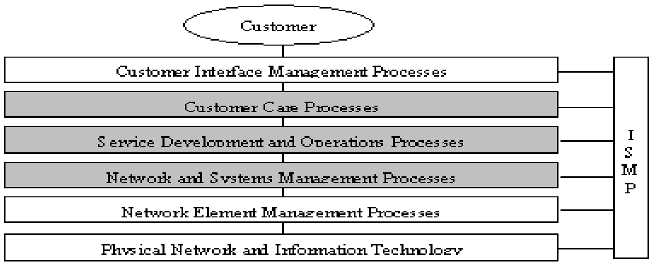
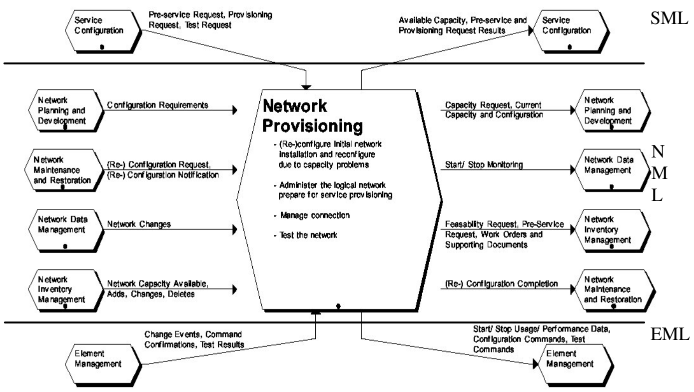


Figure 2. Telecom Operations Map.

TOM brings an initial answer by defining two distinct processes for the provisioning process: the service configuration process and the network provisioning process. These two processes carry out configuration management activities on two different management levels (service and network).



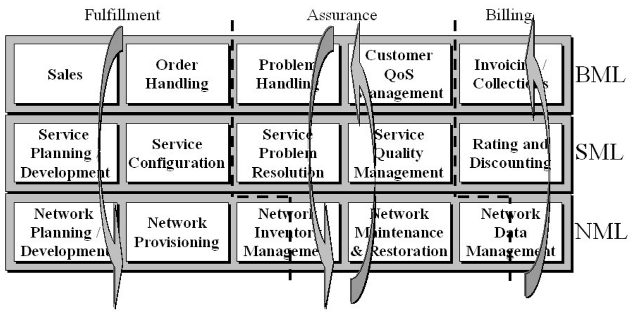


Figure 3. Network provisioning process.

Figure 4. FAB processes flows (TOM).

To contribute to describing end-to-end process flows, TMF defines three types of processes. The three processes are: Fulfillment, Assurance and Billing (fig.4). In this paper, we are interested particularly in the Fulfillment process. It covers the delivery of required services, the configuration management and planning activities. This process contains the principal activities for provisioning which are mapped on service and network management layers.

This split (fig.4) consists in a first attempt to structure the provisioning process. The problem is that this macroscopic view does not simplify the process design and does not meet optimization needs. The fact of seeing a process as a large "black box" does not allow us to facilitate optimization of offered functionalities and thus penalizes the whole process productivity.

2.2.2 Enhanced Telecom Operations Map (eTOM)

To counter the disadvantage previously mentioned of the TOM, the TMF has defined an enhanced model of TOM: the eTOM [8]. eTOM covers a large range of enterprise processes and brings a new vision of process structuring. The method suggested by the eTOM [8][9] brings a solution to the problem of viewing processes as black boxes. The method decomposes process components in five levels. Figure 5 shows a high level view (level 0) of eTOM process grouping. TMF defines three process groups in the eTOM model: "operations", "enterprise management" and "Strategy, infrastructure & product". TOM covers only a part of the "operations" process group. This view offers the advantage of differentiating processes according to their field of activity. The level 0 parts are broken up and produce a second level of detail (fig.6). On this level, the TMF makes a vertical and horizontal subdivisions, except for the Enterprise Management part. The vertical division of the operations part allows the distribution of processes according to whether they contribute to ensuring Fulfillment, Assurance, Billing and Readiness operations (FAB&R). The horizontal subdivision is carried out according to the roles of processes in enterprise management layers. eTOM continues the decompositions and provide three other levels. Figure 7 shows the “operations” level 2 processes.

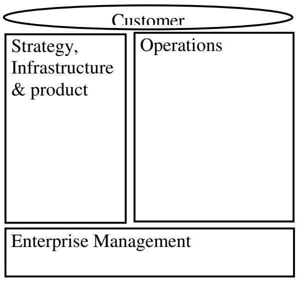


Figure 5. Level 0 processes.

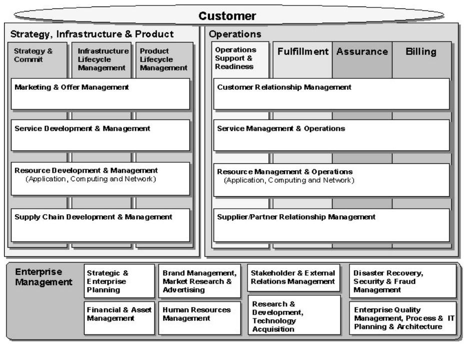


Figure 6. Level 1 processes.

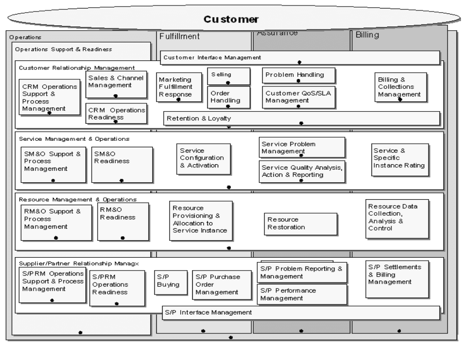


Figure 7. Operations level 2 processes.

Level 4 represents management functions. A function is perceived as being the smallest functional processing entity. Figure 8 gives an example of process decomposition.

Another advantage of eTOM is that it separates two aspects: a static aspect which represents process definition and a dynamic aspect which introduces the concept of process flows. The concepts of workflow management were investigated by the WfMC [10][11]. Figure 9 gives an example of a process flow started by a feasibility request.

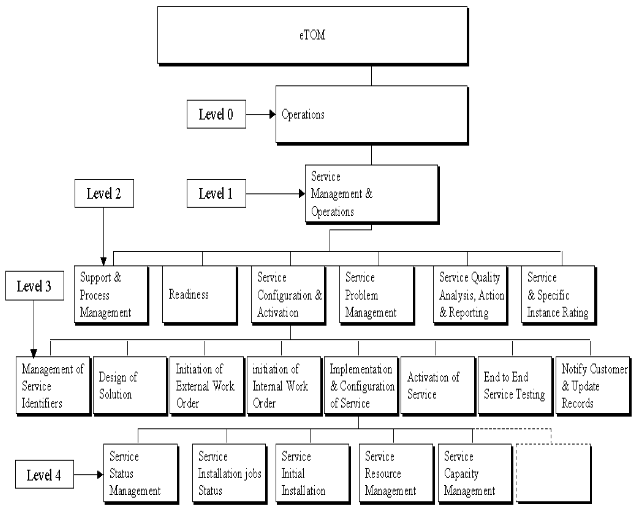


Figure 8. An example of process decomposition.

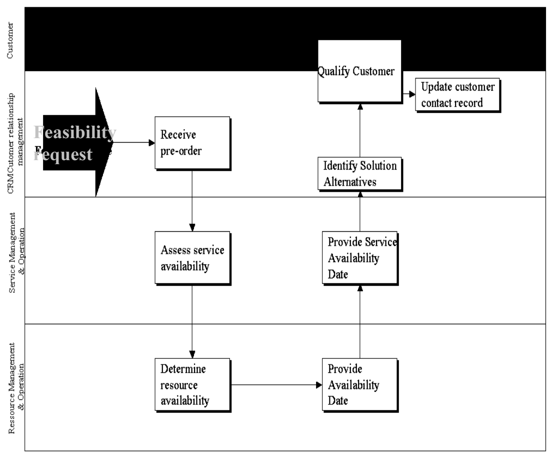


Figure 9. Process dynamics example.

This new way of decomposing functional process tasks is very promising. The methodology offered by eTOM proposes to structure the functional components of processes. This structuring allows the black boxes to be opened and a better design of process components.

2.3. WfMC

The WfMC goes so far as to detail the aspects related to workflows (process dynamics in eTOM). It specifies in particular the transformation from process modeling to process automation [10] and the general architecture of the workflow engines [11]. It also proposes definitions that relate to processes and workflows. The table which follows compares the various definitions of process and workflow given by the eTOM, WfMC and the PILOTE[1] [12] project.

[1] - ‘‘Processus d ’Ingénierie du LOgiciel des TElécommunications’’ (Telecommunication Software Engineering processes). We have mentioned this RNRT project because it offers a meta-model for workflows and also a methodology which offers modeling and implementation of telecommunication processes.

	eTOM	WfMC	PILOTE
Process	Describes a systematic sequenced set of functional activities that deliver a specified result. Process is a sequence of related activities or tasks required to deliver results or outputs.	Business process: a set of one or more linked activities which collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles and relationships.	A process deals with the definition of tasks, the declaration of actors engaged in those tasks, the workproducts, combined with a description of the temporal chaining between the tasks.
Workflow	An end-to-end process flow includes all sub-processes, activities and the sequence required to accomplish the goals of process.	The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules.	

Table 1. Process and workflow definitions comparison.

eTOM, WfMC and PILOTE project agree on a definition of a process as being formed by components and links between components. According to the WfMC, a component represents an activity. An activity is quite a large entity which will have to be structured. PILOTE and eTOM introduce the task which represents an activity component. The links between tasks are governed by sequencing rules. Concerning the definition of a workflow, there is only the WfMC which mentions that a workflow is the result of a process automation. eTOM speaks about process flows only.

2.4 Conclusion on management standards

From our study of the different approaches of TMN, TMF and WfMC, we retained that the end-to-end provisioning uses functionalities located in all TMN management levels. But these functionalities are not detailed for the highest TMN layers. Also, it is necessary to schedule these functionalities. TOM showed the horizontal and vertical relations between the management levels but without a structuring model. The methodology suggested by eTOM describes a decomposition of process components. Information flows exchanged between these components are managed by a workflow engine.

To associate eTOM and WfMC contributions, we propose our view on process and workflow. We state that a workflow is a particular scenario of a process. It describes a particular way or path between process instance components. By applying this proposal, the workflow will thus be able to support new customer service demands and future strategies.

However, a question still remains open: is applying the TMN, TOM, eTOM and WfMC models, standards and methodologies sufficient to have an efficient provisioning process?

3. Provisioning: from problem towards solutions

Generally, in the industrial telecom community, provisioning is associated with the *allocation* of resources on the *network level*. Is this allocation consistent with the standards results? And how are the provisioning activities optimized?

The analysis will be done in several steps. At each step, we use identified key points to provide a part of the solution. Then, we will see how we can take benefit from these solutions to meet our needs.

3.1. Levels related

As we mentioned, provisioning is generally perceived only on the network level. This restricted view of provisioning is mainly due to the incomprehensible vision of "service" as an entity of management.

In accordance with the TMN model, provisioning must be extended to SML and BML levels. Figure 10 shows the application of TMN principles to provisioning. This diagram shows that the complete provisioning process uses functions belonging to the four management layers.

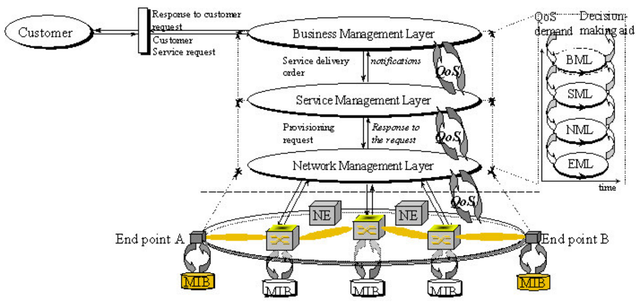


Figure 10. A complete view of the provisioning problem.

We detailed the aspects not covered by the TMN, especially provisioning on NML, SML and BML. EML is largely treated by TMN, so we did not detail it. In figure 10, we represent the customer who asks for a service via an interface to the BML. We suppose that the required service consists of making a connection between the points A and B with a specified QoS.

On BML, provisioning activities of the business level are carried out. After a sale negotiation phase, and according to the SLA contract, provisioning policies, QoS policy rules, performance rules, security rules, fault management rules and usage measurement rules will be created, activated and configured. The client's account will be created, activated and initialized too.

The service request will be translated, by the BML, into a service delivery order. More precisely, there will be a translation of the SLA terms and policies into service level QoS terms (service trail delay, service capacity, service node reliability, …). The service delivery order will start the translation of the customer service into end-to-end technical service components. On the SML, management of logical resource allocation and configuration will be carried out.

The provisioning request, resulting from SML, will be dealt with be the NML. On this level, from service QoS level, the network QoS elements will be produced. To manage the end-to-end flows between A and B, we need a special NML-MIB (Management Information Base), in gray in the figure 10. This MIB is fed by the information collected by end-to-end flow measurements procedures. This also allows us to control of end-to-end QoS. On NML, provisioning functions will be fulfilled. Mainly, we find the management of the resource allocation, the management of logical network capacities, the management of connections and connectivity resources, and the determination of configuration orders that will be sent to network elements. These orders are dealt with by the OMCs (Operational Management Centers) to produce configuration scripts for the physical network elements.

This analysis was carried out by a Top-Down approach (from BML to EML) in which we show how provisioning operations are carried out at each level in a chronological order. We should note that the control plane plays an important role, in particular when the provisioning process uses functions requiring signaling, for example the establishment of connections, cross-connections and routes. So, when provisioning requests are processed, mechanisms belonging to control and management levels are used.

3.2. Resource allocation related

Now let us reconsider the allocation activity. On the network management level, we find a *network* formed by the whole of the potential network partitions (like VPN user sub-networks) connecting user communication points. This network is constituted of user *flows* and logical nodes (protocol instance). User flows are a part of the network level, they are supported by the physical operator network.

To manage the resources, we propose to design finite state machines (FSMs) able to represent the resource usage states. This allows us to have an management event-based approach and to exceed the constraints of the procedural processing. Thus, we designed three FSMs (fig.11). The first FSM (A) relates to the management of a particular instance states. The second FSM (B) relates to the flows management. The third FSM (C) models the resource states of the physical level.

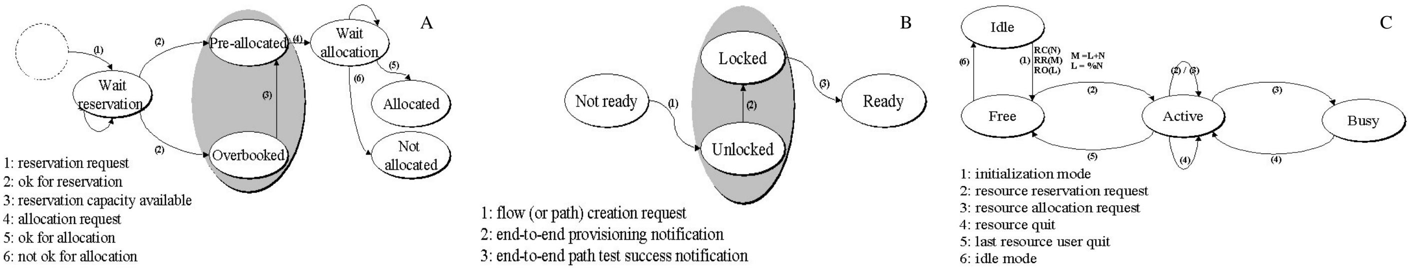


Figure 11. Resource management FSMs.

The process between request capture and service activation (i.e.: the provisioning process) can be very long and we cannot allow the resource being monopolized or reserved too long. Following the example of seat reservations on the airlines (overbooking), it is necessary to anticipate the demand results. The fact of directly allocating resources to a customer can be penalizing for other customers especially if desistance occurs or a requested path with required QoS cannot be found. In these cases, the resources are reserved unnecessarily, and so under-utilized, whereas other customers are on standby for these resources.

A way to by-pass this disadvantage is to introduce a state which materializes an intermediate resource situation before its final allocation (in gray on the FSM A). This state is formed by two sub-states: the "pre-allocated" and the "overbooked" states. These two sub-states indicate the beginning of the resource path reservation activity. The "overbooked" state allows the reception of more reservation requests than the real capacity of the resource. At this state, various operator's strategies to manage resources are applicable.

On the flow management FSM (B), a path creation request causes the transition from the "not ready" state to the "unlocked" state. In the "unlocked" state, all the provisioning work is carried out with by the FSM (A) instance. Once the end-to-end path resources were provisioned, the FSM (B) transits to the "locked" state to start the end-to-end test phase. If all operations are successful, the FSM (B) moves to the "ready" state.

At the resource management FSM (C), a resource has four possible states: Idle, Free, Active and Busy. We propose that the resource uses three "variables" to manage its capacities: RC (Resource Capacity, i.e.: real capacity of the resource), RR (Resource Reservation capacity) and RO (Resource Overbooked: capacity of the resource to be in overbooking). When the FSM moves from the "Idle" state to the "free" state, the parameters of the three capacities are initialized from the operator resource management policies. The “Active” state allows the management of several reservation and allocation request instances. So, there are relations between the FSM (A) and the FSM (C). When a allocation or reservation request is formulated by an instance, the FSM (C) carries out operations on the capacities of the required resource and sends notifications. These notifications allow the change of the FSM (A) sates.

We have proposed the FSMs for the network resource management level. Their generics properties allow us to use them on all the management levels (according to our proposals described in the paragraph 3.1). In this case, the resources are those relating to the considered management level.

3.3. Functional component related

In the two preceding paragraphs, we saw that the provisioning activities (from pre-allocation to configuration) are found on all TMN management layers (from BML to EML). The problem is to find a way to allow this process to be more responsive and more optimized, in order to guarantee the time-to-market criterion.

Let us recall that a process consists of tasks (components) and links between tasks. As a first analysis, we can compare the process to a network in which we must locate the optimal path for each request. To answer our question, we propose to extract, from each process component, all the aspects relating to the *communication* (connection, synchronization, tests, …). This enables us to structure the provisioning process components. The optimal *organization* of the communication will lead to the urbanization of the process. The term "urbanization" was taken from the architecture world. Urbanization is also used in the data-processing domain to improve the information systems [13].

In our case, when we separate communication from processing we obtain some elementary components which we will call granules. When we consider the workflows, we seek to apply rules to optimize the exchanges. Thus, a dynamic *reorganization* of the granules can be done. This is the objective of the urbanization.

The fact of separating the communication from processing permits to have components units that are functionally independent and reusable. Figures 12-a and 12-b show the time saving obtained from process structuring phases and the identification of granules to be processed in parallel.

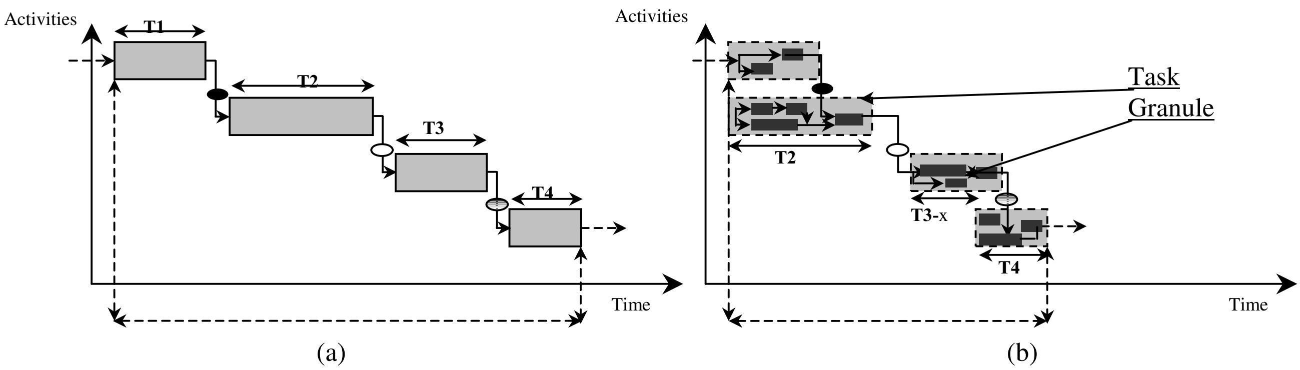


Figure 12. Time saving with process structuring.

Other advantages are envisaged after the process structuring, for example:

- To reduce consumed resources, indeed to frequently call a block requires more resources and more means than calling a component of the block.
- To facilitate evolution and process re-engineering.
- To increase design comfort thanks to the re-useable components.
- To better control process activities, this is necessary to easily ensure process activity monitoring, the detection of errors and the fast and effective resolution of functional problems.

The urbanization process is done before the workflow automation. Statistic measurements (latencies, transfer, operations costs, …) allow us to get an idea on the performances reached and will be able to influence the structuring phase later. This work is called process re-engineering.

3.4. Process flow related

As we saw in the previous paragraphs, the provisioning deals with management functions ranging from BML to EML. The structuring work, presented in this paper, must be carried out on the BSS process level as well as on the OSS process level. Therefore, the provisioning process which calls BSS (CRM) and OSS (service and network management) activities will be facilitated (fig.13). Indeed, the interactions don’t depend on OSS and BSS specific processes. To control this communication, the interaction should be automated. A management tool must take care of this automation: the workflow engine. Before submitting them to the workflow engine, the interactions must be modeled by a *tree of precedence between process components*. Therefore, the engine receives as entry the precedence tree model for provisioning process. It will produce flows considered as particular scenarios of the precedence tree. Hence, this engine will have a visibility of the process flows and this will contribute to making the end-to-end process flows *traceability* (from the BSS to the OSS).

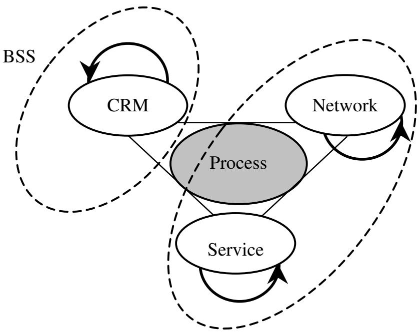


Figure 13. BSS-OSS functional relationship.

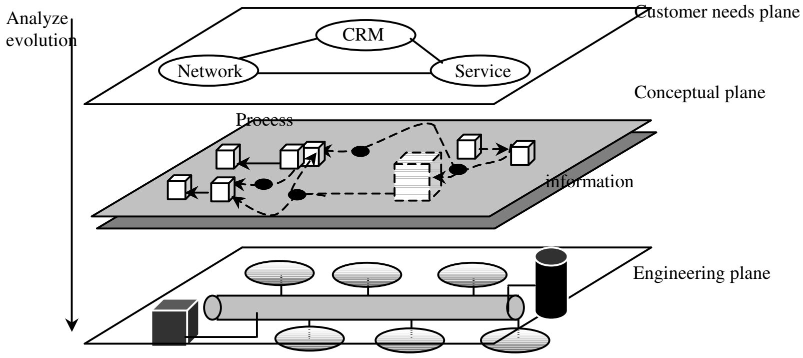


Figure 14. Suggested analyze model.

3.5. Contribution synthesis model

As depicted in figure 14, our whole model is constituted of three different planes: customer needs plane, conceptual plane and engineering plane. These planes cover from the customer needs to the provision of a solution. On the customer needs plane, the customer expresses his requirements (in our case, provisioning process). This plane allows the definition of processes by determining: process roles, process actors and process activities. The activities must represent all process functionalities from the BSS to the OSS. The conceptual plane is constituted of two "sub-planes": the process model plane and the information model plane[2]. On the process model plane, we find the process logic. The process logic is materialized by the precedence tree between process tasks. This tree will be created after having removed all communication aspects from process tasks. The last level (the engineering plane) takes care of the implementation. The communication will be managed by the workflow engine. The control of the processing of parallel tasks can be achieved with a transactional engine. On this last level, the integration will be fundamental to permit to the applications and the engines to support efficiently the provisioning process and to really reflect the time savings, the flows traceability and the flexibility benefits.

4. VPN provisioning process

To illustrate our contributions, we present a VPN provisioning process. The required service is to make a VPN ensuring a connection with a QoS. We apply the provisioning management activities on all management levels (§3.1). We ensure the network provisioning through FSMs (§3.2) and we structure the process components according to our proposals (§3.3). Indeed, the sequence diagram (fig.15) describes the interactions between the management levels (BML, SML, NML, …), the provisioning phases (pre-allocation, allocation, configuration) and the process-actors (order handling, service provisioning, service configuration, …). Table 2 represents the actions carried out by each process-actor.

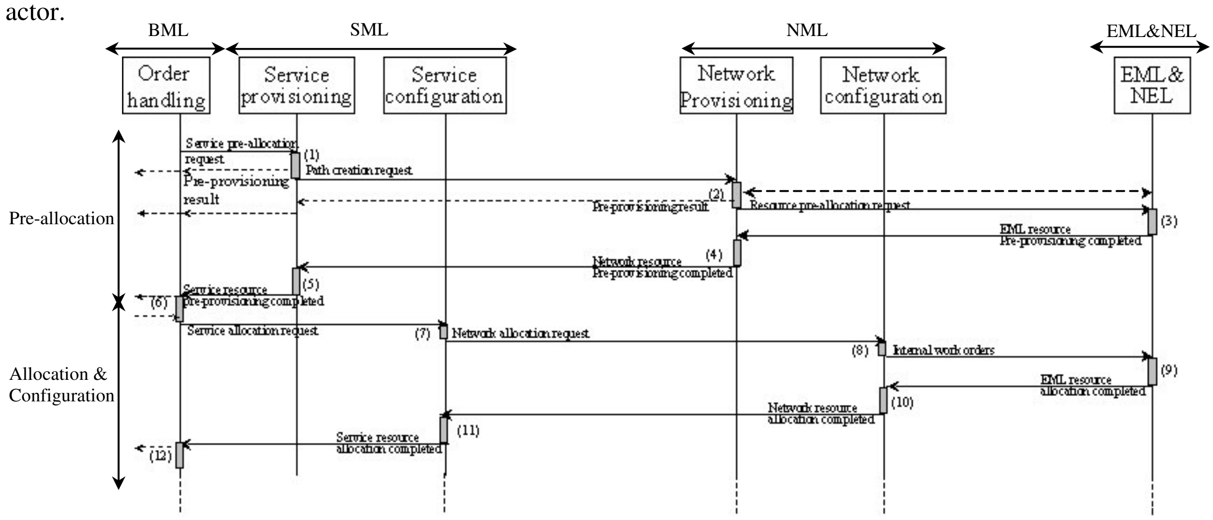


Figure 15. Service and network provisioning process.

N	Action
1	-Receive the request. -Customer service decomposition and service features definition (ex: encoding, authentication, authorization, tunneling, customer profile management, closed user group, failover features, DHCP, …). -Distribution of VPN service features on VPN service nodes. -End-to-end service VPN trail definition (tunnel). -Service resource pre-allocation and service capacity management. -Generate path creation request.
2	-FSM(B)="unlocked"(transition from not ready to unlocked). -For each selected path node: (1) Receive the path creation request.(2) Send requests to resource pre-allocation. (3) FSM(A)="wait reservation". (transition to wait reservation).

[2] - In this article, we focused only on the aspects related to the processes (functional aspects).

3	-For each selected node: (1)Receive the pre-allocation request.(2) if(FSM(C)==”Free” or “Active”) then (1) RR=RR-1, (2) if(RR ≤ L) then RO=RO-1. endif (3) send pre-allocation result(Ok), (4) FSM(C)=”Active”. else (1) send pre-allocation result(NotOk) (2) FSM(C)=”Busy” endif.
4	-For each path node: (1) Receive the pre-allocation result. (2) if(result==”ok”) then if(RO < L) then (1) FSM(A)=”Overbooked”, (2) process strategy operator’s actions, (3) send pre-provisioning results() else (1) FSM(A)=”Pre-allocated”, (2) send pre-provisioning results() endif else Rollback() endif
5	-Receive pre-provisioning results. -context updates. -End-to-end service pre-provisioning results().
6	-Validate end-to-end resource pre-provisioning with user. -order handling actions. -Generate service allocation request.
7	-Receive the allocation request. -service configuration actions. -Generate network allocation request.
8	-Receive the allocation request. -if (FSM(A)==”pre-allocated”)then (1)FSM(A)=”wait allocation”.(2) Generate internal work order units. else event_ignored() endif
9	-Receive the work orders for each selected node. -RC=RC-1. -RR=RR-1. -EML effective resource allocation (Physical ports, Memories, queues, Physical connection points, cross connection, cables, Physical addresses, physical capacities…). -EML effective resource configuration (Access port configuration, Adjustment of cross connection parameters, Adjustments of CPU powers, Adjustments of bits loss rates, Optimize cross equipment times, …). -Validate configuration and allocation. -EML resource status and control settings. -if(RC > 0) then FSM(C)=”Active” else FSM(C)=”Busy” endif -Sends allocation and configuration results()
10	-Receive the allocation results. -if (allocation==ok) then (1) Network resource allocation (Logical ports, Logical capacities, Logical connections points, Virtual links and network trails, Logical addresses, Bandwidth, …) (2) Network resource configuration (Network trail configuration, Network access point configuration, Network protocol parameters adjustment, Bandwidth adjustment,) (3)Validate end-to-end network resource allocation and configuration. (4) network status and control setting. (5) FSM(A)=”allocated” (6) FSM(B)=”locked” (for initiating end-to-end tests). else FSM(A)=”not allocated” endif - send end-to-end provisioning results()
11	-receive the results. -if(result==”ok”) then (1) Service resource allocation (Service access points, VPN tunnel, Service capacities, …) (2) Service features configuration (Service trail (VPN tunnel) configuration, S-SAP configuration., Configure VPN capacity (maximal successfully access number, …)., Configure VPN tunnel exchange delay and rate, …) (3) service status and control settings, (4) service configuration validation, (5) send results() else rollback() endif
12	-Service activation initialization work order.

Table 2. The end-to-end provisioning actions.

5. Conclusion and future activities

In the general context of service and network management, the aim of this work is to provide enhancements to help to reduce the complexity of provisioning. We focused on the functional dimension of network and service provisioning. Pushed by a need for offering services with required QoS, the operators currently attribute great importance to provisioning and the mechanisms governing its functions. We saw that the provisioning functionally connects management functions belonging to management layers. It starts from BML to effective resource reservation on physical network equipment. We have shown also that an efficiency gain can be found when the processes are well understood and the correct functions are well distinguished and have the right links. Knowing these elementary components (granules) it is easier to build provisioning processes for new services. This can be done thanks to the structuring process. The next steps for the industry would be to standardize these processes and workflows and to standardize also interfaces and interface technologies. This would really help to make the integration and co-operation between BSS and OSS systems easier. However, this is not yet sufficient to ensure efficient and flexible provisioning systems. The implementation of the processes in these systems needs to be flexible too.

All this will ensures considerable benefits for the operators. These benefits will be translated into the improvement of the general activity of the company, a fast RoI, an easier reach of strategic objectives and, especially, to support future needs which are not yet envisaged.

This paper gives a start for the provisioning process and it constitutes an open door to our future activities. They will relate to the informational dimension of provisioning. We will also take into account the relations between the functional and informational aspects of provisioning.

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